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# Laws of Nature, Natural Properties, and the *Robustly* Best System

Michela Massimi\*

## ABSTRACT

This paper addresses a famous objection against David Lewis's Best System Analysis (BSA) of laws of nature. The objection—anticipated and discussed by Lewis (1994)—focuses on the standards of simplicity and strength being (in part) a matter of psychology. Lewis's answer to the objection relies on his metaphysics of natural properties and its ability to single out the *robustly* best system, a system that is expected to come out far ahead of its rivals under any standard of simplicity and strength. The main task of this paper is to argue that Lewis's reply to the objection in terms of nature being *kind to us* does not succeed, if nature's kindness is understood in terms of the *naturalness* of the properties composing the Humean mosaic. For epistemic access to natural properties is downstream to any previous identification of the best system. A possible Lewisian rejoinder in terms of a cross-world Humean mosaic of natural properties is considered and rebutted. The paper concludes by suggesting that Lewis could instead avail himself of a better answer to the objection, if the standards of simplicity and strength were reinterpreted along perspectivalist lines.

## 1. INTRODUCTION

What is a law of nature? David Lewis's (1973) influential answer to this question builds upon earlier remarks by J.S. Mill and F. Ramsey: laws are axioms or theorems in the best deductive system. The best system is the system that achieves the best balance (let us call it B) between the standard of simplicity (S) and strength (I, understood as the information content of the system).<sup>1</sup> Lewis's Best System Analysis (BSA) of lawhood is metaphysically modest and Humean in flavour. Laws do not govern nature because they ultimately supervene on non-nomic facts about natural properties in a hypothetical Humean mosaic. If we were omniscient enough to know the full Humean mosaic of non-nomic facts, we would be able to order and systematize the related store of nomic facts (supervenient on them) into a best system (i.e., the one that would deliver laws of nature qua axioms or theorems). Lewis's BSA tacitly assumes some kind of God's-eye access to the Humean mosaic (what Ned Hall has aptly called LOPP, or the Limited Oracular Perfect Physicist [Hall 2015, 15]) to judge how nonmodal facts about the distribution of natural properties map onto

\*Edinburgh University

fundamental laws of nature. On Lewis's account, it is ultimately the job of physics to identify the perfectly natural properties composing the Humean mosaic. The distinction between natural and unnatural properties is taken as primitive.<sup>2</sup> The co-occurrence of specific pairs of natural properties is taken to underpin lawful, regular patterns in nature (for example, the natural property of having half-integral spin co-occurs with the property of being in an antisymmetric state; and their co-occurrence underpins Pauli's exclusion principle).

My main task in this essay is to query the interplay between the Lewisian standards for the Best System and the appeal to sparse natural properties in identifying what Lewis called the *robustly* Best System. My final goal is to argue for the need to supplement Lewis's account of the *robustly* Best System, over and above his appeal to sparse natural properties. Section 2 lays out Lewis's considered answer to what he regarded as the menace of the so-called 'ratbag idealist' to his Best System account of lawhood. Section 3 argues that Lewis's answer in terms of nature being kind to us, and hence ultimately in terms of natural properties, in and of itself does not succeed. Section 4 considers and rebuts a possible Lewisian rejoinder in terms of a cross-world Humean mosaic to define natural properties. Section 4 concludes the paper by proposing a friendly amendment to the Lewisian BSA along perspectivalist lines (building on Massimi [forthcoming]).

## 2. WHAT MAKES A SYSTEM ROBUSTLY THE BEST? NATURAL PROPERTIES AND THE LUNACY OF THE RATBAG IDEALIST

Building on Ramsey's remarks on lawhood, Lewis famously puts forward an account of lawhood which takes contingent generalisations as laws of nature if and only if they feature as theorems or axioms in each of the true deductive systems that achieves the best combination of simplicity and strength (Lewis 1973, 73). The footnote accompanying the relevant passage adds, "I doubt that our standards of simplicity would permit an infinite ascent to better and better systems; but if they do, we should say that a law must appear as a theorem in all sufficiently good true systems" (ibid.). Lewis regards true deductive systems as balancing the standards of simplicity and strength, which from the outset Lewis is willing to concede as *our* own standards (not God's ones; although God has "His standard of truthfulness," which He might bestow upon humankind in the form of a "*Concise Encyclopaedia of Unified Science*"). Thus, lawhood—on Lewis's account—is a contingent property of our best system. Yet lawhood (Lewis warns) is not lawlikeness plus truth: a true universal generalization that is regarded as lawlike would not qualify as a law, unless it featured as either an axiom or a theorem in the best deductive system.

Over the years, Lewis's account has invited reactions to the effect that the chosen standards for the best system (simplicity and strength) are *too* vague to bear the epistemic weight Lewis placed on them. Moreover, Lewis's claim that his account explains why we have reasons for taking the theorems of our well-established scientific theories "provisionally as laws" seems to buy into what Bas van Fraassen has called Lewis's "eschatology of science" (van Fraassen 1989, 59). The claim that "our scientific theorizing is an attempt to approximate, as best as we can, the true deductive

system with the best combination of simplicity and strength” (Lewis 1973, 74) might well belong to an irenic image of how science progresses and unfolds. But it finds no counterpart in the much more mundane details of how—as a matter of daily practice—scientists go about finding laws of nature, or how scientific theories come and go across historical periods.

Aware of the objections, over the years Lewis refined the view to tackle what he deemed the worst lunacy his account could (mistakenly) be held responsible for, *the lunacy of the ratbag idealist*:

The worst problem about the best-system analysis is that when we ask where the standards of simplicity and strength and balance come from, the answer may seem to be that they come from us. Now, some ratbag idealist might say that if we don’t like the misfortunes that the laws of nature visit upon us, we can change the laws—in fact, we can make them always have been different—just by changing the way we think! (Talk about the power of positive thinking.) It would be very bad if my analysis endorsed such lunacy. I used to think rigidification came to the rescue: in talking about what the laws would be if we changed our thinking, we use not our hypothetical new standards of simplicity and strength and balance, but rather our actual and present standards. But now I think that is a cosmetic remedy only. It doesn’t make the problem go away, it only makes it harder to state.

The real answer lies elsewhere: if nature is kind to us, the problem needn’t arise. I suppose our standards of simplicity and strength and balance are only partly a matter of psychology. It’s not because of how we happen to think that a linear function is simpler than a quartic or a step function; it’s not because of how we happen to think that a shorter alternation of prenex quantifiers is simpler than a longer one; and so on. Maybe some of the exchange rates between aspects of simplicity, etc., are a psychological matter, but not just anything goes. If nature is kind, the best system will be *robustly* best—so far ahead of its rivals that it will come out first under any standards of simplicity and strength and balance. We have no guarantee that nature is kind in this way, but no evidence that it isn’t. It’s a reasonable hope. (Lewis 1994, 479)

Let us get clear about the lunacy of the ratbag idealist. The worry is not so much that simplicity and strength come from us and are vague. This is not so much of an issue for Lewis for he is happy to concede that *lawhood* is contingent on our best system. The dreaded lunacy consists, instead, in the unwelcome thought that—insofar as our best deductive system depends on *our chosen standards* of simplicity, strength and balance—the ensuing *laws too* would depend on our choice. Crucially, how laws of nature might depend on us is rather opaque in this non-better-qualified lunacy of the ratbag idealist. In Section 4, I return to this issue and make a couple of distinctions that will hopefully clarify what is genuinely at stake in the idealist menace. But for now, the basic idea is that should the standards change or be different, different laws of nature might ensue from the newly defined best system. The ratbag idealist

would put laws of nature on wheels—making laws of nature themselves (not just lawhood) contingent on our *chosen* best system, after all.

In trying to bar this lunacy, Lewis offers an official metaphysical answer: *if* nature is kind to us, the best system will be *robustly* the best. Laws of nature do not change over time (as we happen to change our way of thinking about the best system) if nature is, ultimately, *kind to us*. But what does our hope that nature is kind to us amount to?

A *prima facie* safe bet is that the Humean mosaic consists of *natural* properties.<sup>3</sup> For unnatural, gruesome properties would be unkind to us in inducing us to draw unwarranted nomic conclusions from our best deductive system (i.e., conclusions that would wildly diverge or even be contradictory after time  $t_1$ ).<sup>4</sup> Thus, the best antidote against the ratbag idealist is some good dose of *naturalness* in the properties composing the Humean mosaic. Regular co-occurrences of the same pairs of natural properties over time would warrant the stability of laws of nature across sufficiently good systems, and ultimately in the *robustly* best system (the system that comes out first out of any rival).

For this reason, I disagree with Loewer's argument that "Lewis's metaphysical notion of natural property is not needed by the BSA and, in fact, undermines what seems to me to be the most attractive feature of the BSA" (Loewer 2007, 316–17). Loewer's argument against the metaphysics of natural properties is motivated by van Fraassen's concerns about the Lewisian eschatology of science. If it were possible to reformulate BSA (as Loewer suggests) without coupling the aim of science with the aim of Lewisian metaphysics, van Fraassen's objection would be met.

Yet, there is a further, and in my view, more pressing motivation for Lewis's appeal to natural properties than securing a natural language in which the simplicity of the atomic predicates for the Best Theory can be evaluated (as Loewer contends).<sup>5</sup> If the line of argument so far is on the right track, Lewis's BSA cannot do away with the metaphysics of natural properties, because natural properties are after all needed to ground Lewis's hope that nature is indeed *kind to us* (against the lunacy of the ratbag idealist). Although the kindness of nature is just a hope, it is nonetheless a reasonable one, Lewis says. It is the kind of hope needed to secure that a Best System can eventually be in place, despite possibly changing standards of simplicity, strength, and balance. Let me then ask: is the Lewisian requirement of natural properties sufficient to deter the lunacy of the ratbag idealist? The next Section assesses the prospects of Lewis's considered response in terms of natural properties with a note of pessimism.

### 3. THE RATBAG IDEALIST RELOADED

Suppose a defiant idealist comes to the fore. Building on Lewis's concession that standards of simplicity and strength are, at least in part, a matter of psychology, the idealist invites us to consider some not-so-far-from-reality variations to the standard of simplicity ( $S_1, S_2, \dots$ ). These variations may capture different standards endorsed by rival scientific communities. For example, a community might understand simplicity in terms of a small number of entities postulated to explain a phenomenon  $p$ . A not-so-outlandish example would be present-day defenders of MOND (or modified

Newtonian gravity) in cosmology as an alternative to the Dark Matter-Dark Energy programme (or more precisely, the  $\Lambda$ CDM model of cosmology). MOND advocates appeal to the simplicity and mathematical elegance of their theory, which assumes modifications to Newton's acceleration law at the cosmological scale, over the rival  $\Lambda$ CDM, which explains some of the same phenomena by introducing new entities (dark matter and dark energy), whose exact nature and existence is still very much a matter of ongoing scientific inquiry. In MOND, no dark matter needs be postulated to explain galaxies's flat rotation curves. This phenomenon is instead explained by assuming that Newton's second law breaks down below a certain threshold.<sup>6</sup> Defenders of the Dark Matter-Dark Energy programme, on the other hand, typically prefer to understand simplicity in terms of avoiding ad hoc modifications to well-entrenched scientific theories (i.e., having to modify Newtonian dynamics, as MOND does). Similarly for a scientific community, information strength might be understood in terms of number of consequences one can derive from the best system. But another scientific community might prefer to understand the same standard in terms of how *explanatory* the information is.

Let us assume then—for the sake of keeping things simple—that there are only two possible variations for both the standard of simplicity and the standard of information content, respectively (in practice, looking at the history of science, many more variations can be found across historical periods and scientific communities).<sup>7</sup> Thus, an idealist may envisage the following logically possible rival scenarios, with different triplets consisting of simplicity  $S_1$  or  $S_2$ , information content  $I_1$  or  $I_2$  and balance  $B_{1-4}$  between simplicity ( $S_1$  or  $S_2$ ), and information content ( $I_1$  or  $I_2$ ):

$$< S_1, I_1, B_1 >; < S_2, I_1, B_2 >; < S_1, I_2, B_3 >; < S_2, I_2, B_4 > \quad (I)$$

The idealist now sets out to test Lewis's assumption that if nature is kind to us, there will indeed be a *robustly* best system, i.e., a system which will come out far ahead of its rivals under *any* of these rival standards of simplicity, information content, and balance. Hence, she invites us to choose the *robustly* best system, among the four possible candidates in (I) in the following way:

Def: *The Robustly Best System*

In world  $w_2$ , if nature is kind to us (i.e., if there is indeed, say, a natural property  $c$ ), the robustly best system will be able to deliver laws of nature about property  $c$  far ahead of any rival system that it will come out first under any standards.

Given the four possible candidates to the Lewisian title of Best System in (I)—viz.,  $<S_1, I_1, B_1>; <S_2, I_1, B_2>; <S_1, I_2, B_3>; <S_2, I_2, B_4>$ —one might ask *which* of these is *the* Best System. The ratbag idealist might invite us to consider three logically possible answers to this question:

1. All four candidates in (I) prove to be *robustly the best*—i.e., each and every of them can deliver laws of nature about natural property  $c$  that fit with

- other laws about other natural properties in  $w_2$ , under any combination of the varied standards.<sup>8</sup>
2. None of the four possible candidates in (I) proves *robustly the best*—i.e., each and every of them proves incapable of delivering laws about  $c$  that fit with other laws about other natural properties in  $w_2$ , under any combination of the varied standards.<sup>9</sup>
  3. One and only one of the four candidates in (I) turns out to be *robustly the best* (this is Lewis's favourite answer, of course, based on the reasonable hope of nature's kindness to us).

If nature is kind to us, Lewis's Best System Analysis must establish (3) as the only valid answer in this menu. But how can Lewis's BSA establish (3)? Once again, presumably, one might appeal to the naturalness of the properties involved in the Humean mosaic. There can only be *one* robustly best system, namely the one capable of tracking the Humean ordered  $n$ -tuple of natural properties  $\langle a, b, c, \dots, n \rangle$  composing the mosaic. Thus, the definition of the robustly best system should be amended as follows:

Def. 2: *The Robustly Best System*

In world  $w_2$ , if nature is kind to us (i.e., if there is indeed, say, a natural property  $c$ , which is part of an ordered  $n$ -tuple of natural properties  $\langle a, b, c, \dots, n \rangle$ ), the robustly best system will be the one able to deliver laws of nature about property  $c$  and about its companion natural properties at world  $w_2$ , far ahead of any rival system that it will come out first under any standards.

After all, one should expect the Lewisian robustly best system to deliver not just one law about one natural property  $c$ , but instead several laws about several natural properties regularly co-occurring at world  $w_2$ . What are the prospects for such a robustly best system?

Let us go back to our example from cosmology, and let us assume—all else being equal—that two rival systems running neck and neck diverge only as far as simplicity  $S$  is concerned. MOND understands simplicity along the lines of avoiding unnecessary new entities ( $S_1$ ). The Dark Matter-Dark Energy (DM-DE) programme understands simplicity along the lines of simple mathematical equations that do not break down below a certain threshold ( $S_2$ ). Hence, the two rival systems can be expressed as  $\langle S_1, I_1, B_1 \rangle$  and  $\langle S_2, I_1, B_2 \rangle$  (where a different balance  $B$  in each case takes care of the difference between  $S_1$  and  $S_2$ ). The robustly best system is expected to come out far ahead of its rival, if nature is kind to us. What would it be like for nature to be *kind to us* in this case? How to choose between MOND and DM-DE?

One might expect nature to point us to the relevant natural property  $c$  in the Humean mosaic (and its close companions) that might allow us to distinguish between the two rival systems and point us to the robustly best one. But what would such natural property be? It might be either a property  $c_1$  concerning a particular kind of Newtonian dynamics, which breaks down below a certain acceleration scale  $a_0$ . Or, it might be a property  $c_2$  concerning dark matter. Were nature kind to us, one



would expect nature to point us in the right direction as to whether  $c_1$  or  $c_2$  is the relevant natural property, whose non-nomic facts the nomic facts in the robustly best system should supervene on. But of course, unless Ned Hall's LOPP comes to the rescue, there is no way one can ever know in advance whether  $c_1$  or  $c_2$  is the case.<sup>10</sup> In fact, it is ultimately the choice between our two candidate best systems that will adjudicate the case as to whether—to the best of our knowledge— $c_1$  or  $c_2$  is the relevant *natural property*. And the choice between our two candidate best systems is dictated by various motivations, not least by consensus gathering within the scientific community about the perceived theoretical virtues and experimental evidence for DM-DE over MOND, for example. Thus, the Humean mosaic of natural properties cannot be expected to act as a metaphysical anchor for choosing the robustly best system. For our reasonable hope in the kindness of nature (in pointing us to the right natural properties) is downstream to scientists' choice between sufficiently good rival systems. Our reason for thinking that sparse natural properties have been identified is a byproduct of scientists' choosing the best system, in the first instance. The ratbag idealist strikes back. Natural properties do not, after all, provide a safe metaphysical anchor against the idealist menace, if our only epistemic access to them is via the robustly best system, which (often enough) happens to be our *currently preferred* best system, e.g. DM-DE (in the absence of LOPP, and scientists of its ilk). Natural properties do not secure the kindness of nature against this reloaded idealist threat, which (through the lenses of current rival cosmological models) does not seem, after all, such an out-of-this-world lunacy.

At this point, a Lewisian might reply along the following lines. Let us concede that we do not know in advance whether  $c_1$  or  $c_2$  is in fact a natural property in the Humean mosaic. As of today, for example, the scientific community has not conclusively settled on the existence of dark matter, so as to rule out entirely the possibility of an anomalous Newtonian acceleration that breaks down below a certain scale (as MOND would have it). This detail notwithstanding, if nature is kind to us—the Lewisian goes on—the robustly best system will still come out far ahead of its rival. The robustly best system will (one day in the near future) include laws about either  $c_1$  or  $c_2$ —we just do not know which *yet*; but it is a reasonable hope and is what we aspire to in our theory-building. Only regularities concerning either  $c_1$  or  $c_2$  that most contribute to the overall best balance of simplicity and strength will count as laws in the robustly best system.

This Lewisian rejoinder does not make the problem disappear. But it somehow deflates it. For it would seem that—despite us not having LOPP-ian access to natural properties—natural properties could still fulfil their primary metaphysical task: securing that laws of nature are not on wheels by our ever changing standards of simplicity and strength. There might be facts about the Big Bang (such as the Past Hypothesis), or facts about dark matter that we may or may never come to confirm (or even discover). But insofar as these non-nomic facts feature somehow in the Humean mosaic (even if we do not have epistemic access to them), we can expect them to work within the mosaic to make nature overall kind to us and in pointing us to the robustly best system. The next Section probes a bit further this possible Lewisian rejoinder.



#### 4. CROSS-WORLD HUMEAN MOSAIC TO THE RESCUE?

Consider some slight variation to the Humean mosaic where our ordered  $n$ -tuple of natural properties may indeed include properties that we do not know as yet (either because we have not discovered them yet; or because they have been postulated but not experimentally found; or because we simply cannot have epistemic access to them, or else). Let us assume in particular that our natural property  $c$  is under a veil of ignorance, so to speak, at time  $t_n$  in world  $w_2$  (say, our world now) when the scientific community has not settled yet as to whether  $c_1$  or  $c_2$  holds. According to a suitable amendment to the Lewisian story, one can imagine that if nature is kind to us, natural property  $c$  (be it  $c_1$  or  $c_2$ ) and non-nomic facts about it, should nonetheless feature in other possible worlds ( $w_1, w_3, w_4, \dots, w_j$ ). And, if nature is indeed kind to us in this way, then the transitivity holding among possible  $n$ -tuples of  $(n - 1)$  natural properties in a cross-world Humean Mosaic  $HM_{w1-wj}$  would secure that non-nomic facts about natural property  $c$  provide a safe metaphysical anchor for the robustly best system at *our current* world  $w_2$  (even if  $c$  is under a veil of ignorance there).<sup>11</sup> In other words, even if  $c$  may be under a veil of ignorance in our world  $w_2$  now, it is its naturalness in a cross-world Humean Mosaic  $HM_{w1-wj}$  that ultimately explains how  $c$  can be made to work (with its companion natural properties) to single out the robustly best system at  $w_2$ . Let us unpack this possible Lewisian amendment to the story so far.

This amendment is compatible with Lewis's view that a natural property in, say, world  $w_1$  must be natural in any other world (given what it is to be a natural property); but it does not need to be instantiated in every possible world (and may well be hidden under a veil of ignorance at  $w_2$ ). Suppose now that different natural properties, one at the time, may go uninstantiated (or maybe they are instantiated but under a veil of ignorance like  $c$  is at  $w_2$ ) in different possible worlds. Hence, the following variations to the respective Humean mosaics of various worlds  $w_1 - w_j$ :

$$\begin{aligned} &\langle a, c, d, \dots, n \rangle \text{ in } w_1 \\ &\langle a, b, d, \dots, n \rangle \text{ in } w_2 \\ &\langle b, c, d, \dots, n \rangle \text{ in } w_3 \\ &\dots \end{aligned} \tag{II}$$

The cross-world Humean mosaic is a disjunction of ordered  $n$ -tuples consisting of all and only  $(n - 1)$  natural properties across possible worlds  $w_1 - w_j$ :

*Cross-world Humean mosaic of natural properties:*

$$\begin{aligned} HM_{w1-wj} = &\langle a, c, d, \dots, n \rangle_{w1} \cup \langle a, b, d, \dots, n \rangle_{w2} \\ &\cup \langle b, c, d, \dots, n \rangle_{w3} \cup \dots \end{aligned} \tag{III}$$

For nature to be kind to us, it would have to be the case that—despite  $c$  being under a veil of ignorance at world  $w_2$ —the transitivity relation among the  $n$ -tuples  $(n - 1)$  of natural properties in the cross-world Humean mosaic (III) would nonetheless secure that  $c$  does feature in other possible worlds as a natural property. Hence, the burden of discriminating the robustly best system at world  $w_2$  among the possible candidates in (I) would ultimately fall on the cross-world  $HM_{w_1-w_j}$  and its kindness to us. The cross-world  $HM_{w_1-w_j}$  would prove kind to us if it could guide us towards the robustly best system at world  $w_2$ . Such a robustly best system would have to come out far ahead of all its rivals in (I), despite different standards of simplicity  $S_1$  and  $S_2$  selecting either  $c_1$  or  $c_2$  as the relevant natural property in  $w_2$ , and despite us being under a veil of ignorance (in  $w_2$ ) as to whether  $c_1$  or  $c_2$  holds.

There seem to be only two possible options for the cross-world Humean mosaic to display such kindness to us at world  $w_2$ . The first relies on what I am going to call the *Uniqueness Thesis*. The second resorts to some kind of *Ur-Best System*. Let us examine each option in turn. A first option would be to assume that it is possible to map different best systems to different worldly  $n$ -tuples among the ones captured by the cross-world Humean mosaic  $HM_{w_1-w_j}$ . This mapping of different sets of nomic facts onto different worlds  $w_1-w_j$  of non-nomic facts about  $(n - 1)$  natural properties would have to be such that there is one and only one set of nomic facts for each worldly class of  $(n - 1)$  natural properties. In this way, the *robustly best system* could be identified with the set (and the only set) of nomic facts that maps onto the worldly class of natural properties  $(n - 1)$  at world  $w_2$ . This one-to-one mapping of best systems and worldly classes of natural properties  $(n - 1)$ —among the ones included in the cross-world Humean mosaic  $HM_{w_1-w_j}$ —would require something along the lines of:

### *Uniqueness Thesis*

Given world  $w_2$ , and the ordered  $n$ -tuple  $\langle a, b, d, \dots, n \rangle_{w_2}$  belonging to the cross-world Humean mosaic  $HM_{w_1-w_j}$ , there ought to be *one and only one* of the four logically possible candidates for best system in (I) that is *robustly the best system* at world  $w_2$  in virtue of tracking the correct  $n$ -tuple  $\langle a, b, d, \dots, n \rangle_{w_2}$  of natural properties at world  $w_2$  (*mutatis mutandis* for any other world among  $w_1-w_j$ ).

The *Uniqueness Thesis* forces upon us the view that the *robustly best system* has to be the one (and the only one) that tracks the particular mosaic distribution of natural properties *instantiated in our world*  $w_2$  (but not the properties instantiated in  $w_1$ ,  $w_3$ , or any other world). After all, the laws delivered by the *robustly best system* are contingent on the world we happen to live in, and they could have been different, had we lived in a different world with a slightly different set of natural properties. The *Uniqueness Thesis* is meant to yield a clear winner (the robustly best system) for each possible world among those included in the cross-world Humean mosaic. How credible is the *Uniqueness Thesis*?

For the thesis to work, it would have to prevent scenarios like the aforementioned one where it is possible that more than one system, among the four ones in (I),

maps onto the same worldly distribution of natural properties  $\langle a, b, d, \dots, n \rangle_{w_2}$  at  $w_2$ . Given the veil of ignorance at world  $w_2$  about property  $c$ , the *Uniqueness Thesis* would have to prove that it is not possible for the two candidate best systems  $\langle S_1, I_1, B_1 \rangle_{w_2}$  and  $\langle S_2, I_1, B_2 \rangle_{w_2}$  to both map onto the set of natural properties  $\langle a, b, d, \dots, n \rangle_{w_2}$ .

But the *Uniqueness Thesis* lacks resources to prevent the possibility of rival best systems mapping onto the same set of natural properties. Indeed, the *Uniqueness Thesis* simply tells us that there ought to be one and only one of the four logically possible candidates for best system in (I) that is *robustly the best system* at world  $w_2$ . But it does not tell us how to go about *securing* the sought-after one-to-one mapping to prevent the above scenario, where more than one system (with slightly varied standards of simplicity) can in fact map onto the very same worldly set of natural properties at world  $w_2$ . In other words, that natural property  $c$  (be it  $c_1$  or  $c_2$ ) features in other mosaic distributions for other possible worlds among those in the cross-world Humean mosaic, does nothing to point us in the right direction for identifying the robustly best system at  $w_2$ . For there are no cross-world mechanisms for how non-nomic facts about natural properties at worlds  $w_1, w_3$ , or else, may provide an indication for what the robustly best system ought to be at  $w_2$ . Worse, there are no cross-world mechanisms that could prevent scenarios where more than one candidate rival system at world  $w_2$  maps onto the same  $n$ -tuple of natural properties at  $w_2$ . Thus, the *Uniqueness Thesis* does not prove that there has to be a one-to-one mapping between nomic and non-nomic facts about natural properties for each world  $w_1-w_j$  if not 'by fiat', i.e., by ultimately relying on whatever laws of nature happen to be delivered (once again) by our currently accepted best system at world  $w_2$ . In the absence of cross-world mechanisms to map the correct  $n$ -tuples of  $(n - 1)$  instantiated natural properties at any world  $w$ , with the one (and only one) set of laws of nature in that same world, the *robustly best system* turns out to be (once more) nothing but *our currently accepted system* at world  $w_2$ . The *Uniqueness Thesis* is itself only a cosmetic remedy against the idealist comeback.

A second *prima facie* more promising option may appeal to some kind of *Ur-Best System*. The intuition behind this second option is more modest than the one behind the *Uniqueness Thesis*. For no one-to-one mapping is invoked in the expectation to deliver the robustly best system. Instead, the four logically possible candidates for best system in (I) may be *collectively* taken as composing a—so to speak—*Ur-Best System* that supervenes on the equivalence class of cross-worldly  $(n - 1)$  natural properties captured by the cross-world Humean Mosaic  $HM_{w1-wj}$ . The *Ur-Best System*, as a whole, would map onto the disjunction of worldly natural properties across worlds  $w_1-w_j$ , so as to secure that there has to be *a* robustly best system (among rival ones) for a worldly distribution of natural properties.

But that's the most that the *Ur-Best System* can also tell us. Namely, that *some n-tuple of natural properties in the cross-world Humean mosaic provides the supervenience basis for some robustly best system among those in the Ur-Best System*, without telling us which  $n$ -tuple or which robustly best system. For there is no intraworld mechanism for choosing which system of laws at world  $w_2$  comes ahead of any rival in supervening on natural properties  $\langle a, b, d, \dots, n \rangle_{w_2}$  at world  $w_2$  (*mutatis mutandis* for any

other world). In other words, let us grant that there is a robustly best system in the Ur-Best System:

*Ur-Best System*

$$(< S_1, I_1, B_1 > \cup < S_2, I_1, B_2 > \cup < S_1, I_2, B_3 > \cup < S_2, I_2, B_4 >)_{w_2}$$

To single out the robustly best system, one would need to prove a more substantial claim than the innocuous and nonilluminating claim that the *Ur-Best System* supervenes on the cross-world Humean mosaic  $HM_{w1-wj}$ . For, once again, in the absence of mechanisms for mapping any of the disjuncts in the *Ur-Best System* to any of the disjunct  $n$ -tuples in  $HM_{w1-wj}$ , the possibility of singling out the robustly best system among rival ones fades away.

Moral: the Lewisian possible rejoinder in terms of cross-world Humean mosaic of natural properties cannot deflate the idealist comeback. Either the Lewisian rejoinder buys into a restrictive thesis such as the *Uniqueness Thesis* without providing a mechanism for mapping nomic facts to non-nomic sets of natural properties in each and every world. Or the Lewisian rejoinder concedes too much with the *Ur-Best System* without explaining how any candidate to the best system title (among all possible ones) could ever pick out an  $n$ -tuple of natural properties rather than any other from the cross-world Humean mosaic.

The kindness of the cross-world Humean mosaic at world  $w_2$  seems then to reduce to the claim that if we happen to live in the world we do, with the properties that there happen to be, then the best system that we happen to have historically developed turns out to be the *robustly* best one! And this might not sound a very satisfactory response to the reloaded ratbag idealist.

Is this bad news for Lewis's BSA? Not entirely. In the next and final section, I foreshadow a different way of answering the ratbag idealist on Lewis's behalf. This further friendly amendment to Lewis's BSA does not rely so much on the robustly best system being able to pick out the right  $n$ -tuple of natural properties. Instead, it relies on the robustly best system being able to single out the same axioms and theorems across a *perspectival series* of best systems, defined by historically changing standards of simplicity, strength, and balance. Hence, ultimately, the robustly best system that can eschew the ratbag idealist is, I am going to suggest, a *perspectivalist better best system*.<sup>12</sup>

## 5. A PERSPECTIVALIST BETTER BEST SYSTEM AGAINST THE RATBAG IDEALIST

Let us take stock and remind ourselves of the idealist threat that Lewis regarded as sheer lunacy. The worry, expressed in Lewis's long quote in Section 2, was that an idealist might come to the fore, who might put on wheels laws of nature via ever-changing standards of simplicity and strength. If these standards are ultimately dependent on us, by changing them, the laws of nature too would be vulnerable to change. Hence, Lewis appeals to nature's kindness (and, to natural properties) as a

way of deterring the idealist lunacy, with all the problems I have expounded in Sections 3 and 4.

But here is another response available to Lewis, a response he did not consider, but which is nonetheless congenial to his view that lawhood is contingent on us and what happens to be our best system (without putting laws of nature themselves on wheels). Consider how our standards of simplicity and strength have historically evolved, and how different scientific communities have come to regard simplicity, for example, either in terms of deriving the causes of motion from the simplest principles (e.g., Newton's force laws); or in terms of integrating the Lagrangian function of the variables of state over all the possible paths a mass point might take, and choose the one with the smallest value (Hamilton's principle). Or consider how the standard of strength has changed in the passage from the best system where Descartes's original law of momentum conservation featured (to explain elastic collisions between solid bodies); to our current best system, where momentum conservation is still deployed to search for Beyond Standard Model physics (e.g., missing transverse momentum in particle collisions is a possible signature for Beyond Standard Model particles) at the Large Hadron Collider, CERN.

It is not just in contemporary cosmology that we witness rival standards of simplicity currently at play in the choice between DM-DE vs. MOND. The evolution of our standards of simplicity and strength is stark across the history of science (think of simplicity and strength in Lavoisier's system of chemistry, where conservation of mass originally appeared, and in Einstein's relativity theory where mass conservation reappears as energy conservation, i.e.,  $E = mc^2$ ).<sup>13</sup> Similarly, stark is the resilience of our fundamental laws of nature across historically evolving best systems (e.g., from mass conservation to momentum conservation). These brief remarks can provide the platform for a more promising (in my view) reply to the ratbag idealist.

The ratbag idealist seems to conflate two distinct notions of *dependence-on-us* (so to speak). The standards of simplicity and strength may be dependent-on-us in a first sense that they depend on features of our psychology, our language, our conceptual make-up. Lewis presumably had in mind this first notion of *dependence-on-us* in devising strategies to deflect the ratbag idealist via nature's kindness. But, I contend, this first notion of *dependence-on-us* does not have a genuine bite, and should not be the cause of concerns for Lewis (and his followers). For unless some persuasive Berkeleian idealist or Goodmanian constructivist argument can be made to the effect of denying to simplicity and strength the very normative role of 'standards'—acknowledged and used by well-established scientific communities—the threat posed by the envisaged ratbag idealist amounts to sheer lunacy (as Lewis himself called it).

However, a second notion of *dependence-on-us* proves at once more plausible and worrisome. For simplicity and strength may depend on us in the sense of being dependent on the established scientific practice of real scientific communities across time. Rather than some far-fetched Berkeleian or Goodmanian scenarios, the lunacy of the ratbag idealist finds its more dangerous reincarnation in a much more realistic and mundane notion of *dependence-on-us* displayed by real scientific communities across historical periods. Is Lewis's BSA going to succumb to it?

My answer to the question is ‘no’, with a caveat: i.e., provided Lewis’s BSA is amended to reject the Lewisian idea that the standards are fixed once and for all (LOPPian standards) and accepts instead the perspectivalist idea that these standards depend on the epistemic needs of scientific communities, which use them to monitor the ongoing performance of scientific knowledge claims (in this case, nomic claims) over time. In [Massimi \(forthcoming\)](#), I have called simplicity and strength *standards of performance adequacy* (among many others which are not relevant to the specific discussion of Lewis’s BSA here). They are standards that allow scientific communities across historical times to assess how well laws of nature inherited from previous scientific communities fare over time. Nomic claims that no longer fare well on the score of balancing simplicity and strength get discarded over time; those that continue to fare well are retained. The *perspectivalist* twist to Lewis’s Best System that I have called in [Massimi \(forthcoming\)](#) ‘novel perspectival Best System Account’ (*npBSA*) suggests that

Given a scientific perspective *sp*, and given simplicity, strength, and balance ( $SSB_{sp}$ ) qua standards of performance adequacy, laws of nature are axioms or theorems of the *perspectival series* of best systems, which satisfy  $SSB_{sp1}$ ,  $SSB_{sp2}$ ,  $SSB_{sp3}$ , and so forth.

The main rationale of this perspectivalist twist to Lewis’s BSA is to take on board the evidence coming from the history of science about the resilience of our fundamental laws, despite historical changes in what counts as the ‘best system’ (from Lavoisier to Einstein, in the example of mass conservation). The clear advantage of the move is to turn what looks *prima facie* as a serious shortcoming of Lewis’s view (the idealist threat) into a feature that can easily be accommodated by Lewis’s BSA under the *perspectivalist* twist I am suggesting to it.

But I want to conclude this paper by mentioning an additional bonus of the perspectivalist twist. If the suggestion is correct, it has also the potential of answering van Fraassen’s famous criticism (mentioned at the beginning of this paper) against Lewis’s “eschatology of science.” For while it is not the case that scientists intentionally go about building the best system (as van Fraassen correctly points out), there is a sense in which the Lewisian best system might emerge as the ideal system along the lines of (*npBSA*), i.e., across scientific perspectives by the end of the inquiry. The perspectivalist Best System is nothing over and above the perspectival series of (historically well-defined) best systems, which have happened to satisfy evolving standards of simplicity, strength, and balance across scientific perspectives ( $SSB_{sp1}$ ,  $SSB_{sp2}$ ,  $SSB_{sp3}$ , and so forth). Our beloved laws of nature are nothing over and above axioms or theorems that have proved resilient across the perspectival shifts of (historically well-defined) best systems. This move is congenial to a more general, Kantian-inspired view of the systematic unity of science qua ‘perspectival knowledge’.<sup>14</sup> Lewis’s quest for a Best System can be regarded as the Kantian search for a systematized body of knowledge; a search which is never fully realized at any given historical time but remains nonetheless a regulative idea of scientific inquiry across scientific perspectives. In the Appendix to the Transcendental Dialectic of the



*Critique of Pure Reason* Kant described the quest for systematic unity in our scientific knowledge as a *focus imaginarius*. As a vanishing point allows painters to draw in perspective, systematic unity allows scientists to pursue scientific research as if there were an imaginary goal. But the goal is imaginary and never given. Is this “eschatology of science” by other names? It is not. Instead, it is a (Kantian) hope, one that Lewis (and Lewisians) could avail themselves of, for it proves at least as reasonable as (if not more reasonable than) the hope in nature’s kindness.

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## NOTES

1. The best balance is the balance that maximizes in a way simplicity and strength, which are notoriously standards pulling in opposite directions. For simplicity would seem to recommend fewer assumptions in the deductive system (at the potential cost of reducing the information content that can be deduced).
2. “Unless we are prepared to forgo some of the uses of the distinction between natural and unnatural properties, we shall have no easy way to define it without circularity. That is no reason to reject the distinction. Rather, that is a reason to accept it—as primitive, if needs be” (Lewis 1983, 344).
3. On Lewis’s natural properties, see Lewis (1983, 1986). For a critical discussion of Lewis’s natural properties in the context of classical physics, see Butterfield (2006) and Weatherson (2006). For naturalness in Lewis, see Weatherson (2013) and Dorr and Hawthorne (2013). For more general discussions about Humean Supervenience, naturalness and modality see Beebe and MacBride (2015) and Weatherson (2015).
4. To appreciate why natural properties matter so much in this context, consider the following Goodmanian scenario, where the natural property of having *half-integral spin* for a particle is accompanied by a non-natural gruesome property of having *half-integral spin\**. *Half-integral spin\** can be thought of as the Goodmanian property of being examined before time  $t_1$  (say, 2020) and having half-integral spin; or, being examined after time  $t_1$  (2020) and having integral spin. If the Humean mosaic included any such non-natural gruesome properties alongside the natural ones, two rival systems could run neck and neck. In one system (let us call it A, where natural property *half-integral spin* features) it would be a law of nature (our spin-statistics theorem) that *All half-integral spin particles are fermions and all integral-spin particles are bosons*. In another rival system (let us call it B where property *half-integral spin\** features), it would be a law of nature (a spin-statistics theorem\*) that *All half-integral spin\* particles are fermions and all integral-spin particles are bosons*, which implies that after time  $t_1$  (2020) all integral spin particles are fermions and all integral-spin particles are bosons! The assumption of natural properties is then key to avoid this kind of Goodmanian scenario where rival systems might be concocted (out of unnatural properties) whose unnatural kinds partially overlap with natural kinds—e.g., half-integral spin\* particles—with possibly contradictory ensuing nomic claims.
5. According to Loewer, Lewis’s main motivation for introducing natural properties is the desire to fix a natural language NL in which the BSA can be formulated to avoid the charge of trivialization:

“The first work that Lewis put natural properties to do was to pick out a language NL relative to which the Best Theory is evaluated with respect to simplicity. Recall that he motivated the introduction of natural properties into his characterization of laws because the system axiomatised by ‘(x) Fx’ (where ‘Fx’ is a predicate true of all and only individuals that exist at the actual world) apparently maximizes simplicity and informativeness and so counts as the best system of the world. The consequence is that all true generalisations are laws. Lewis’s remedy is to add the requirement that the atomic predicates in

the language of a Best Theory refer to perfectly natural properties—where these are properties that do all the metaphysical work Lewis assigns them.” (Loewer 2007, 324)

Loewer argues that such a charge can in fact be avoided, without having to buy into the metaphysics of natural properties that makes Lewis vulnerable to van Fraassen’s objection.

6. “For disk galaxies MOND is more economical, and more falsifiable, than the DM paradigm” (Bekenstein 2010, 5).
7. I discuss some examples taken from the history of science in Massimi (forthcoming).
8. For example, it might be the case that each and every of these four possible candidates in (I)—viz.,  $\langle S_1, I_1, B_1 \rangle$ ;  $\langle S_2, I_1, B_2 \rangle$ ;  $\langle S_1, I_2, B_3 \rangle$ ;  $\langle S_2, I_2, B_4 \rangle$ —satisfies Lewis’s criterion of achieving the best balance between their respective criteria of simplicity and strength. For example, it might be argued that the balance  $B_2$  between  $S_2$  and  $I_1$  is different from the balance  $B_3$  between  $S_1$  and  $I_2$ ; nonetheless,  $B_2$  and  $B_3$  are both the best balance that can be achieved given those two variations of the two standards of  $S$  and  $I$ . As a result, it might be the case that the laws delivered by each of these four different candidates to the Lewisian title of Best System are partially overlapping, partially different. Yet each candidate qualifies for the title of The Best System in achieving the best balance that can be achieved given the specific variations of standards  $S$  and  $I$ . I thank Angela Breitenbach for helpful discussions on this point.
9. After all, why there must be necessarily a Best System, if not by Lewis’s fiat? It might be the case that each and every one of these four possible candidates to the title of Best System fails in different ways in achieving the best balance between their respective variations in the standards of simplicity and strength.
10. There is a wider debate about natural properties that I do not have the space to address here, with scholars defending a view similar to my point above (i.e., natural properties are downstream to accepted scientific theories); others denying that any evidence might ever be available to tell us whether something is a natural property; and a further group of scholars defending natural properties. See D.H. Mellor (2012), Nolan (2015), and Nanay (2014) for some examples.
11. D.H. Mellor (1977, 306) appeals to the transitivity in the equivalence class of possible cross-world samples of ‘water’, which might lack some of the important constitutive properties, as an argument against Putnam’s essentialism about natural kinds. Mellor intends the example as an argument for Fregean descriptivism against Putnam’s emphasis on bearing the same microstructural-kind relation to archetypes on planet Earth to define natural kinds. Here, in a very different context, I see the argument from the cross-world Humean mosaic as a possible friendly amendment to Lewis’s appeal to natural properties to single out the robustly best system, given Lewis’s modal realism.
12. I have introduced this terminology and a preliminary discussion of a novel perspectivalist Best System Account of lawhood in Massimi (forthcoming), on which I draw and expand in Section 5.
13. I discuss all these examples in Massimi (forthcoming), to which the reader is kindly referred if interested in more historical details.
14. I develop the notion of *perspectival knowledge* in relation to Kant’s systematic unity as a regulative idea of scientific inquiry in Massimi (2017).

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